PATENT SPECIFICATION

496,346

Convention Dates (Germany)	Corresponding Applications in United Kingdom	
Jan. 29, 1937:	No. 3051/38	dated Jan. 31, 1938.
Oct. 23, 1937:	No. 3052/38	
Jan. 5, 1938:	No. 3053/38	

(One Complete Specification Left under Section 91 (2) of the Patents and Designs Acts, 1907 to 1932.)

Specification Accepted: Nov. 29, 1938.

COMPLETE SPECIFICATION

Improvements in or relating to Fuel Injection Pumps

We, AUTO UNION AKTIENGESELLSCHAFT, of 110 Scheffelstrasse, Chemnitz, Germany, a Company organised under the laws of Germany, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to fuel injection pumps, and more particularly to port-controlled pumps for injecting fuel in internal combustion engines.

It has already been proposed to construct double-plunger pumps without valves the pump cylinders of which are provided with an inlet port and with a delivery port, one plunger effecting the admission suction whilst closing the delivery port and the other plunger effecting the delivery pressure whilst closing the induction port. However, such construction is not of the type with differentially acting plungers and the movements of the two plungers have characteristics which for each plunger are determined independently of those for the other plunger, and no means are provided to simplify the drive of the two plungers.

In fuel injection pumps of the differential type in which the delivery port is not controlled by one of the pistons, it is known to drive the two pistons by cams which are equal but out of phase.

The object of the present invention is to provide an improved fuel injection pump with a simplified drive for the pump pistons.

According to the present invention a port-controlled fuel injection pump has two independently driven differentially acting pistons one of which controls the inlet port and the other the delivery port, the movements of both pistons having substantially the same characteristics, but out of phase, the piston controlling the inlet port being in advance of the other piston.

The pistons may be driven by identical cams arranged with their effective faces out of phase with relation to each other, and may pass through chambers which they enter from above, said chambers being in communication with the inlet and delivery passages.

The cams may be mounted on parallel shafts, one of which is adjustable about its own axis so as to vary the amount of phase displacement with respect to the other shaft, and means may be provided for effecting the adjustment.

A further feature consists in a multi-delivery fuel injection pump comprising a plurality of pump units according to the invention, each pump unit having a detachable cylinder block, all the cylinder blocks being identical and assembled in juxtaposition.

Each cylinder block may have external positioning faces parallel to the plane passing through the axes of the cylinders and adapted to abut against adjacent cylinder blocks and/or the pump housing, the cylinder blocks of the assembly being clamped together and to the pump housing and the sides of the pump housing may be removably secured so as to permit removal of the cylinder blocks without dismantling the rest of the pump.

Other features of the invention will be apparent from the following description of a few forms of fuel injection pump made in accordance with the invention and their operation, reference being made to the accompanying drawings wherein:—

Fig. 1 is a simplified sectional view of a pump;

Fig. 2 a graph showing the characteristics of the piston movements in Fig. 1;

Fig. 3 a sectional elevation of one constructional form of pump;

Fig. 4 a simplified view and graph, similar to Figs. 1 and 2, of the form of pump shown in Figs. 5 to 7;

Fig. 5 a sectional elevation of an adjustable form of pump;

Fig. 6 a section on the line VI—VI of

Fig. 5;

Fig. 7 a top plan part of Fig. 6 with the lid removed and

Fig. 8 a sectional elevation of a multi-delivery pump, being a section on the line VIII—VIII of Fig. 5.

The same reference characters have been used throughout to denote like parts.

As shown in Figs. 1 and 2, two pump pistons 2, 3 are co-axially mounted in the bore 4 of a pump cylinder 5. The upper pump piston 2 plunges into a chamber 6 formed by an enlargement of the bore 4 in which the inlet passage 7 ends. The other pump piston 3 plunges into a chamber 8 formed by an enlargement of the bore 4 from which branches off the delivery passage 9. The pistons 2 and 3 in Fig. 1 are not shown in their proper relative positions. The pump pistons 2, 3 are driven to move with the same characteristics, which is given by the time-distance curves 10, 11. The upper piston 2 is in advance of the lower piston 3 by the angle ϕ. The characteristic curves of the movements of the two pistons are sine curves, use being made of the fact, that the ascending and the descending portions of phase-displaced sine curves are approximately parallel, thus ensuring that the fluid volume enclosed between the two pistons during the transitory stages between admission and delivery remains substantially constant and can be displaced with no substantial change in the pressure occurring.

Describing this now in detail, in the first section of cycle of operation (α), which commences with the closing of the chamber 6 and ends with the opening of the chamber 8, the two pistons move in substantially constant spaced relation, the distance a between the pistons 2, 3 remaining substantially constant and the curves 10 and 11 being substantially parallel during this stage. The fluid quantity between the pump pistons 2, 3 is accelerated.

In the second section of the cycle of operation (β), which commences with the opening of the chamber 8 and ends with the closing of the chamber 8, the pistons move relatvely to one another, the distance between the pistons a being reduced to b during this stage, whereby part of the fluid quantity between the pistons 2, 3, viz. the part corresponding to the difference c between the distances a and b, is urged into the delivery passage 9, and is injected into the internal combustion engine.

In the third section of the cycle of operation (γ) which begins with the closing of the chamber 8 and ends with the opening of the chamber 6, the pistons 2, 3 again move in substantially constant spaced relationship, the distance b between the pump pistons 2, 3 remaining substantially constant. The fluid quantity remaining between the pistons 2, 3 is retarded during this stage. Accelerating the fluid during the travel α of the pistons, i.e., before the commencement of the delivery stroke, and retarding the fluid during the travel γ of the pistons, i.e., after completion of the delivery stroke, facilitates the allotment of the quantity of fuel for injection in the internal combustion engine.

The sections α and γ of the curves 10, 11 are not exactly, but only approximately, parallel, owing to the phase displacement ϕ. Accordingly a small change in the fluid volume between the pistons 2, 3 during these stages will be unavoidable. This change of fluid volume, however, is readily compensated for by the natural leakage inherent to the piston mounting. It does not, therefore, affect the principle of operation of the pump, of which the decisive factor remains that during the intermediate stage (β) a substantial change in the volume of the fluid must occur which is utilised for the injection of the fuel in the internal combustion engine.

In the form shown in Fig. 3 the pump pistons 2, 3 are adjacently arranged in the pump cylinder 5. The bores 12, 13 are in communication by a transverse bore 14. The pump pistons 2, 3 are driven by identical cams 15, 16 through roller tappets 17, 18. The cam 16 is displaced relatively to the cam 15 by the angle $180°—\phi$, resulting in the piston movements being displaced by ϕ. The pump pistons 2, 3 are loaded by compression springs 19, 20, which abut against the pump cylinder 5 and act on the spring abutment washers 21, 22 connected to the pump pistons 2, 3. The cams 15, 16 and the roller tappets 17, 18 are mounted in a common gear casing 23 to which access is given by a lid 24 and which is connected to the pump cylinder 5 by an interposed member 25.

The operation of this pump, which is one of the forms the pump described with reference to Figs. 1 and 2 will take in practice, corresponds to the operation already described with reference thereto if the bores 12, 13, 14 are imagined to be aligned to lie co-axially with one another corresponding to the bore 4.

The piston 2 plunges from above into the chamber 6, which results in the advantage that no gas bubbles can get into the bore 12. This enables the pump to handle fluids which according to experience tend to evaporate readily; for

with the present construction any gas bubbles evaporated rise to the top of the chamber 6, where they are clear of the piston 2.

In another form of pump shown in Figs. 5 to 7, provision is made for the amount of phase displacement between the cams to be adjustable to enable adjustment of the quantity injected in the engine to be made.

As shown in Fig. 5, the pump pistons 2, 3 are mounted to lie parallel in a common pump cylinder block 5; they plunge from above into the chambers 6, 8 which are in communication with a transversely extending inlet passage 7 and with a delivery passage 9 respectively, a delivery pipe 9*a* being connected to the latter. The cylinder bores 12, 13 in which the pistons 2, 3 slide are in communication by a transverse bore 14. The pump pistons 2, 3, as in the previous construction, are driven by identical, but out-of-phase, cams 15, 16, through roller tappets 17, 18 against the action of the compression springs 19, 20. The eccentrics 15, 16 are mounted on parallel shafts 15*a*, 16*a* which rotate in bearings 29, 30 in the gear casing 23. As can be seen from Figs. 6 and 7 the driven shaft 16*a* drives the shaft 15*a* through a pair of permanently meshing pinions 27, 28. The pinion 28 is fast on the shaft 16*a*. The pinion 27 which is mounted in a bearing 31 in the gear casing 23 so as to be secured against axial displacement, engages a screw thread 36 on an intermediate sleeve 35, which can therefore be caused to rotate independently of the pinion 27. The intermediate sleeve 35 is keyed on the shaft 15*a* by means of the keyway 34 so as to be axially displaceable thereon. At the end 37 of the intermediate sleeve 35 there engages a control rod 40 through a ball bearing 38 acting as a double thrust bearing through the flanges 39.

The shafts 15*a*, 16*a* rotate in opposite directions at the same angular velocity. When adjusted to minimum delivery, the cam 15 is in advance of the cam 16 by the angle $180°—\phi_1$. If the distance of the two pistons 2, 3 on opening the delivery passage 9 be a_1, and on closing the delivery passage 9 on the other hand it be b_1, then the quantity delivered per revolution, f being the piston cross-section,

$$\min Q = (a_1 - b_1)\ f = c_1\ .\ f.$$

For this amount to be delivered by the pump the control rod 40 must be at a distance e_1 from the wall of the gear casing 23. When the pump is adjusted to maximum delivery the cam 15 is in advance of the cam 16 by the angle $180°—\phi_2$. If, in this case, the distance of the two pistons 2, 3 on opening the delivery passage 9 be a_2, and on closing the delivery passage 9 it be b_2, then the quantity delivered per revolution

$$\max Q = (a_2 - b_2) f = c_2\ .\ f.$$

For this amount to be delivered by the pump the control rod 40 must be at a distance e_2 from the wall of the gear casing 23.

For adjustment of the delivery from min Q to max Q the control rod therefore need only be adjusted by the distance $e_2—e_1$ whereby the intermediate sleeve 35, sliding in the keyway 34 on the shaft 15*a* is turned in the screw threads 36 of the stationary pinion 27, causing the shaft 15*a* to rotate about its own axis by the angle $\phi_2—\phi_1$. It is of course possible for the control to be adjusted to any value intermediate of minimum and maximum. The duration β of the delivery stroke remains constant in any adjustment. The duration of the transitory stages of conveying the fluid between the pistons only alters, α_1 at minimum delivery being reduced to α_2 at maximum delivery, whilst γ_1 is enlarged to γ_2. The adjustment to max Q is not infinitely large, but has a practical limit in so far as the duration of the stroke γ can only be increased to an extent leaving the fluid volume enclosed between the pump pistons during that stage sufficiently constant, as it will be seen from Fig. 4 that while the fluid volume constance during the stroke α improves with the angle ϕ increasing, the fluid volume is subjected to increasing reduction and compression in the course of the stroke γ. It is of course possible for the output of the pump to be stopped altogether by reducing the angle ϕ of phase advancement to zero.

In the form shown in Fig. 8, the pump according to Figs. 5 to 7 is equipped as a multi-delivery pump, four separate identical pump cylinder blocks 5 being assembled in juxtaposition. The cylinder blocks 5 have positioning faces P parallel to the plane E passing through the axes of the two pump pistons in each cylinder block, the positioning faces P being arranged to contact with one another and with positioning faces at the inside of side members 5*a* forming the pump casing and holding the cylinder blocks together by means of three clamping bolts 41 (see also Fig. 5) passing transversely through the side members 5*a* and all the cylinder blocks 5. Flanges on the side members 5*a* serve to secure the pump casing to the

spring housing 25 by means of lateral vertical clamping bolts 42. The cylinder blocks 5 have a common inlet passage 7 formed by equal bores in the cylinder blocks, sealing washers 44 being interposed between the positioning faces P to surround and seal the joints in the inlet passage. The chambers 6 are also common to all cylinder blocks, being a continuous groove along the bottom of the inlet passage 7, as can be seen more clearly from Fig. 5. The common inlet passage 7 is extended through one of the side members 5*a* by means of an equal and aligned bore therein and outside the pump casing it is connected to an inlet pipe 7*a*. The combined cylinder blocks 5 thus suspended on the bolts 41 in the pump casing as already stated, are connected to the common spring housing 25, which in turn is secured to the gear casing 23 which is also common to the whole cylinder block assembly and is adapted to be secured to a part of the internal combustion engine by securing members 43.

The individual cylinder blocks 5 are all absolutely identical and are detachable and interchangeable, so that on one of them becoming defective or developing a leak or suffering some other damage, only that particular cylinder block alone need be replaced. This enables the cost of repairs and replacements to be reduced to a most economical figure. The individual cylinder blocks are relatively small components and are simple and easy to cast and to machine.

The removal of one of these cylinder blocks 5 is effected by first removing the bolts 42 and detaching the side members 5*a* with the whole of the combined cylinder blocks 5 from the rest of the pump; thereupon the defective cylinder block is detached from the rest by unscrewing the clamping bolts 41 and replaced by a new cylinder block. The cylinder blocks 5 are then re-assembled in juxtaposition and clamped together between the side members 5*a* by means of the clamping bolts 41, after which the combined cylinder blocks are against suspended on the rest of the pump by securing the bolts 42 to the spring housing 25 and the gear casing 23.

It is of course possible for the multi-delivery pump to be composed of pump units other than those shown in Figs. 5—7; for example, it could be assembled of units of the type shown in Fig. 3.

It will be seen that with a fuel injection pump made in accordance with the present invention, the utilisation of two pistons, the movements of which have equal characteristics which, graphically, are equal, phase-displaced curves, enables the advantage of certainty of operation, i.e., effective delivery stroke and substantial constance of pressure during the transitory part of the strokes, to be combined with simplified drive, resulting in economical manufacture, and with adjustability of the delivery.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Port-controlled fuel injection pump having two independently driven differentially acting pistons, one of which controls the inlet port and the other the delivery port, the movements of both pistons having substantially the same characteristics, but out of phase, the piston controlling the inlet port being in advance of the other piston.

2. Fuel injection pump according to claim 1, characterised in that the pistons are driven by identical cams arranged with their effective faces out of phase with relation to each other.

3. Fuel injection pump according to claim 1 or 2 characterised in that the pistons pass through chambers which they enter from above, said chambers being in communication with the inlet delivery passages.

4. Fuel injection pump according to claim 2 characterised in that the cams are mounted on parallel shafts, one of which is adjustable about its own axis so as to vary the amount of phase displacement with respect to the other shaft.

5. Fuel injection pump according to claim 4, characterised in that the shafts are coupled together by permanently engaged pinions, of which the driving pinion is fast on its shaft whilst the driven pinion is angularly adjustable on its shaft.

6. Fuel injection pump according to claim 5, characterised in that an intermediate sleeve between the driven pinion and its shaft is provided, which is screw threaded to engage the pinion and which is slidably mounted on a spline on the shaft, the pinion being secured against axial displacement, whereby axial displacement of the intermediate sleeve causes rotation of the shaft in the screw thread relatively to the pinion.

7. Fuel injection pump according to claim 6 characterised in that a control rod co-axial with the intermediate sleeve is connected thereto through a double-thrust bearing.

8. Multi-delivery fuel injection pump comprising a plurality of pump units according to any of the preceding claims, characterised in that each pump unit has a detachable cylinder block, all the cylin-

der blocks being identical and assembled in juxtaposition.

9. Multi-delivery fuel injection pump according to Claim 8 characterised in that each cylinder block has external positioning faces parallel to the plane passing through the axes of the cylinders and adapted to abut against adjacent cylinder blocks and/or the pump housing, the cylinder blocks of the assembly being clamped together and to the pump housing.

10. Multi-delivery fuel injection pump according to Claim 9 characterised in that the sides of the pump housing are removably secured for the purpose described.

11. Multi-delivery fuel injection pump according to claim 8, 9 or 10 characterised in that a common gear casing and a common spring housing is provided for the whole of the cylinder block assembly.

12. Multi-delivery fuel injection pump according to any one of claims 8 to 11, characterised in that a common fuel inlet passage for the whole of the cylinder block assembly is provided passing transversely through each cylinder block and the pump housing, sealing washers being provided between the cylinder blocks.

13. Port-controlled fuel injection pump constructed, arranged and adapted to operate substantially as hereinbefore described with reference to Figs. 1 to 7 of the accompanying drawings.

14. Multi-delivery fuel injection pump constructed, arranged and adapted to operate substantially as hereinbefore described with reference to Fig. 8 of the accompanying drawings.

Dated this 31st day of January, 1938.
MEWBURN, ELLIS & CO.,
70 & 72, Chancery Lane, W.C.2,
Chartered Patent Agents.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1938.

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Fig. 1.

Fig. 2.

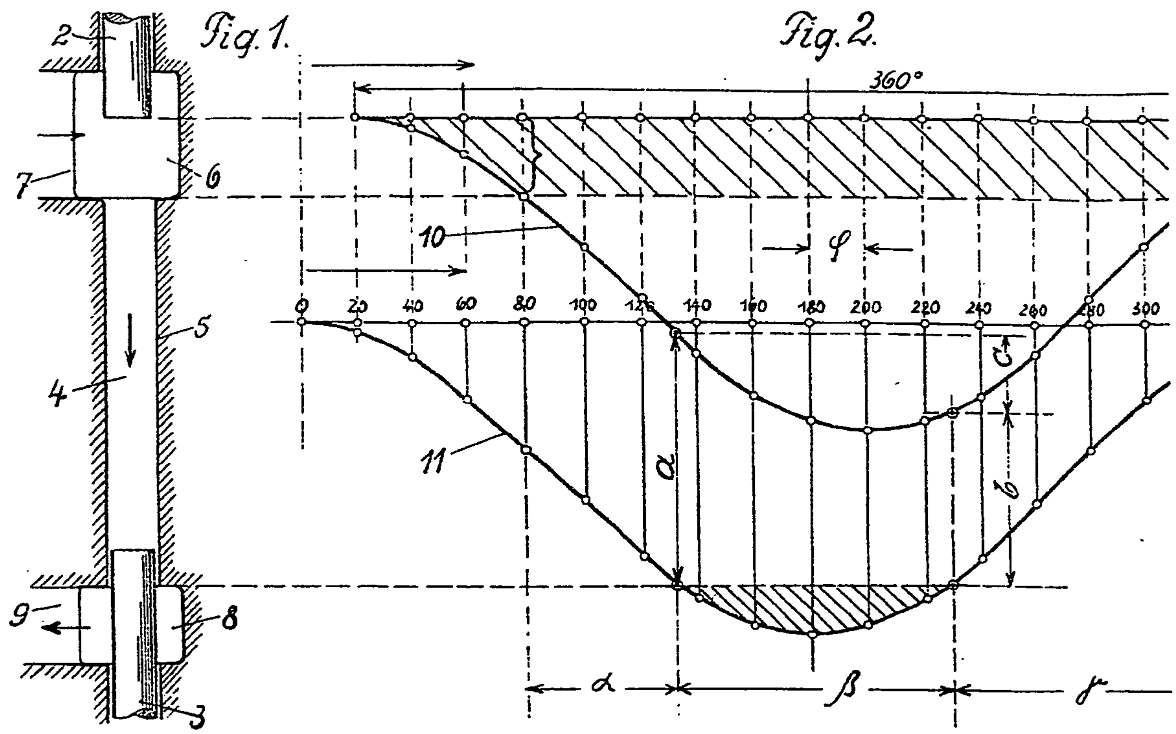
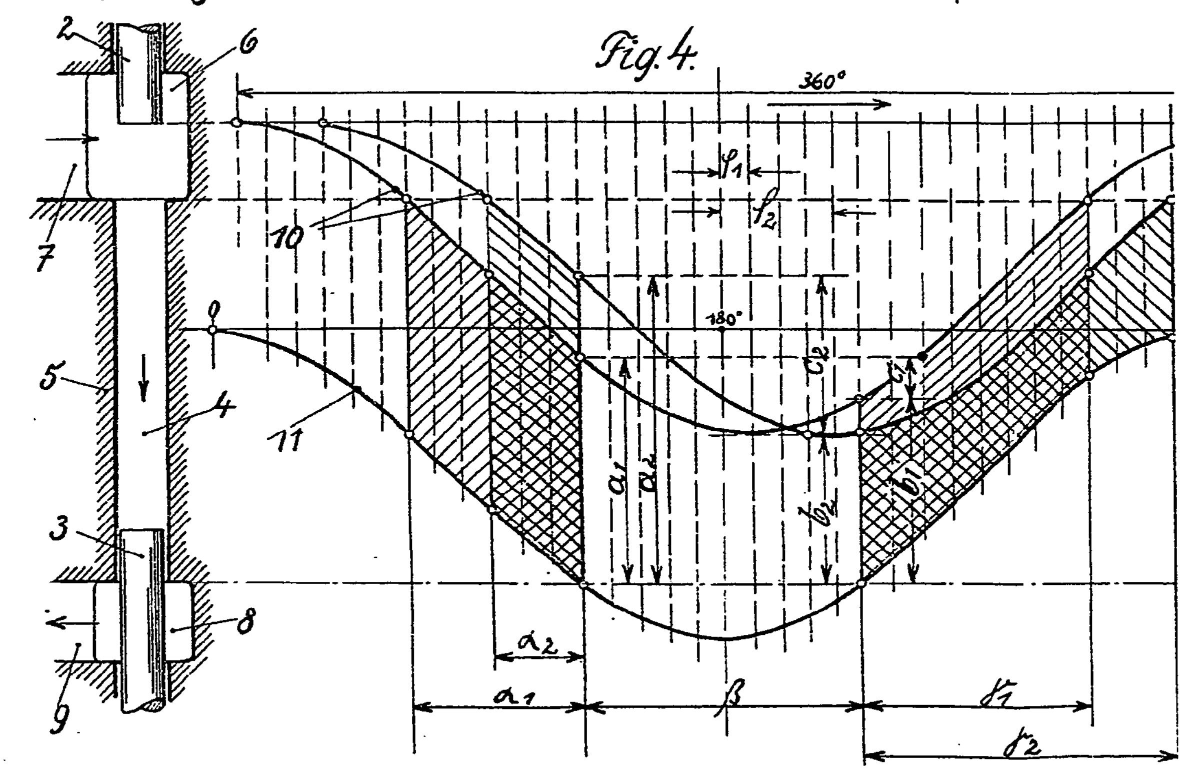


Fig. 4.



2 SHEETS
SHEET 1

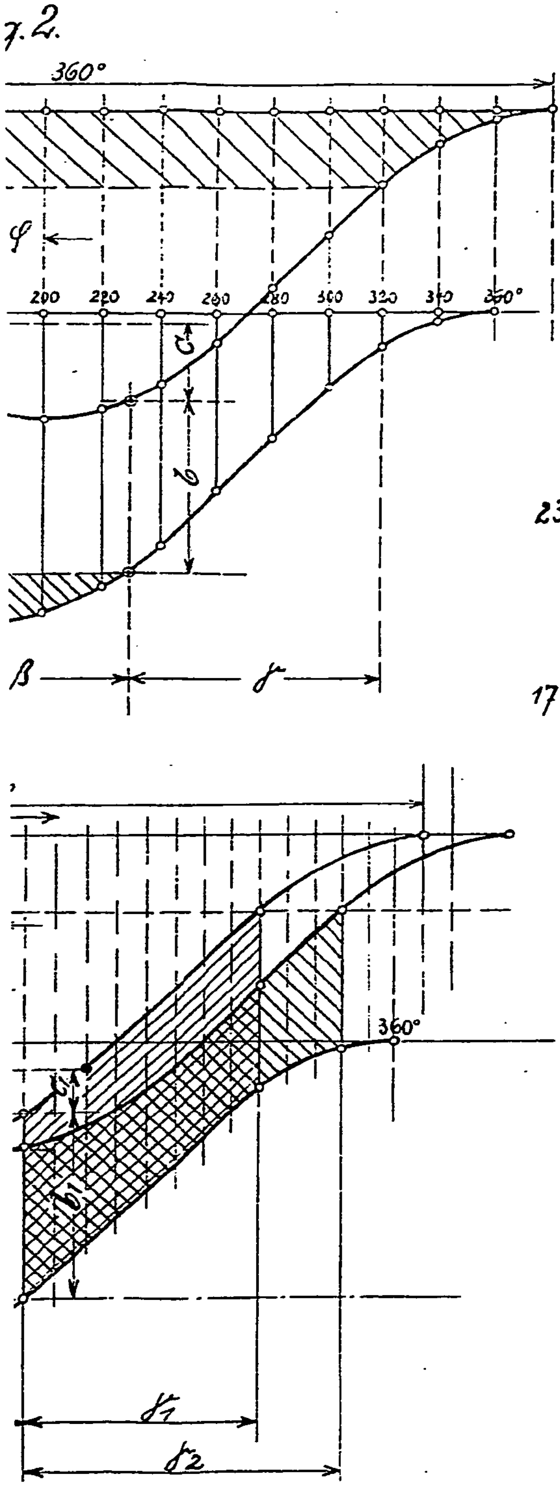


Fig. 3.

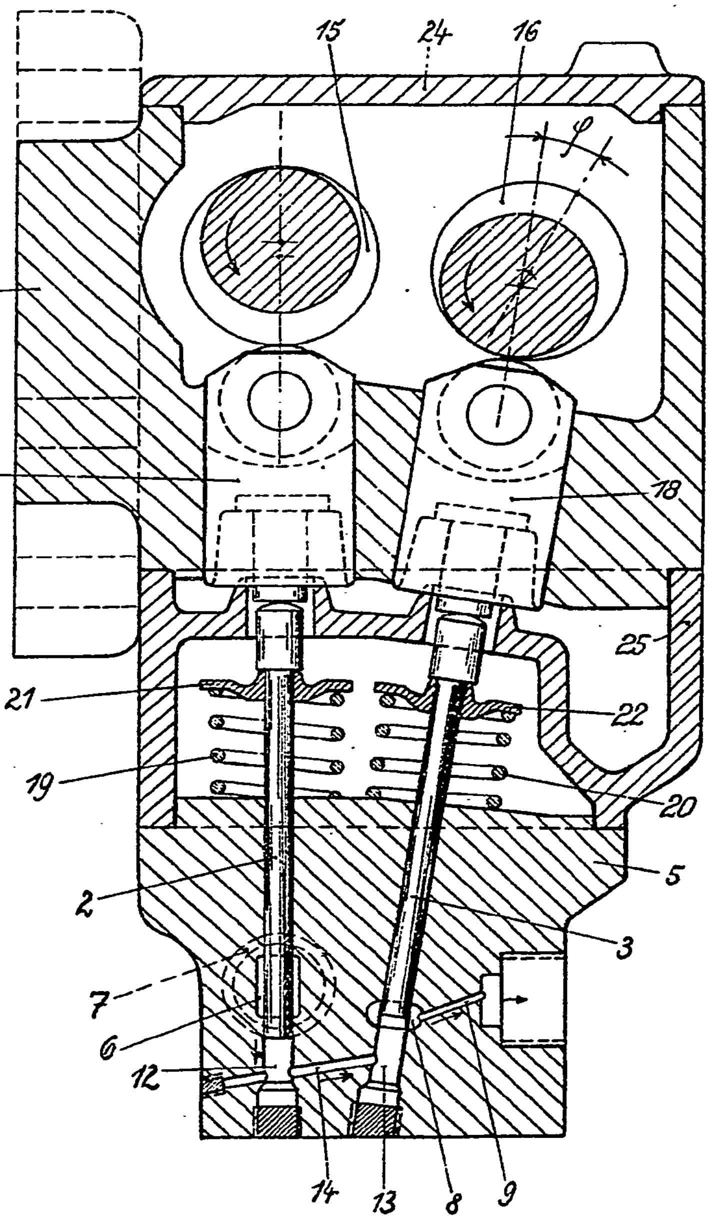


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Fig. 1.

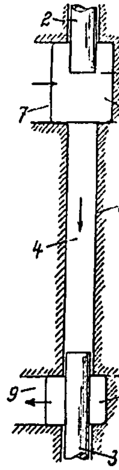

Fig. 2.

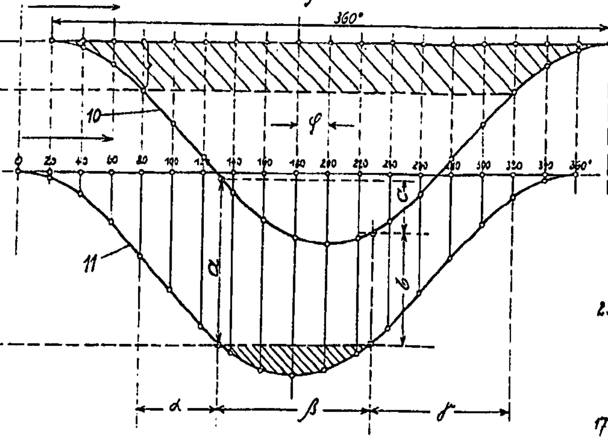

Fig. 3.

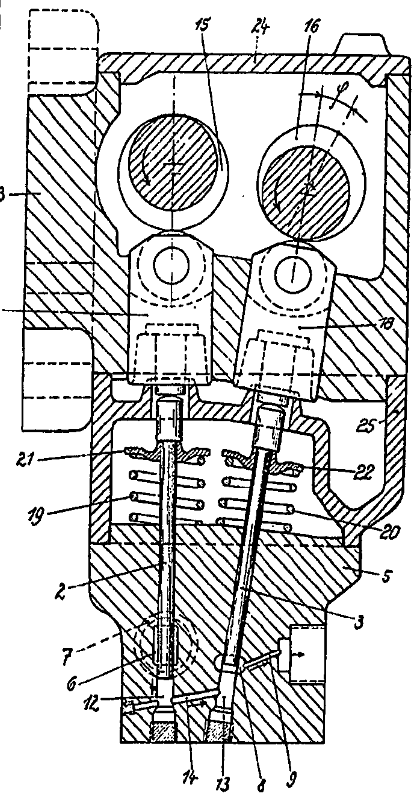

Fig. 4.

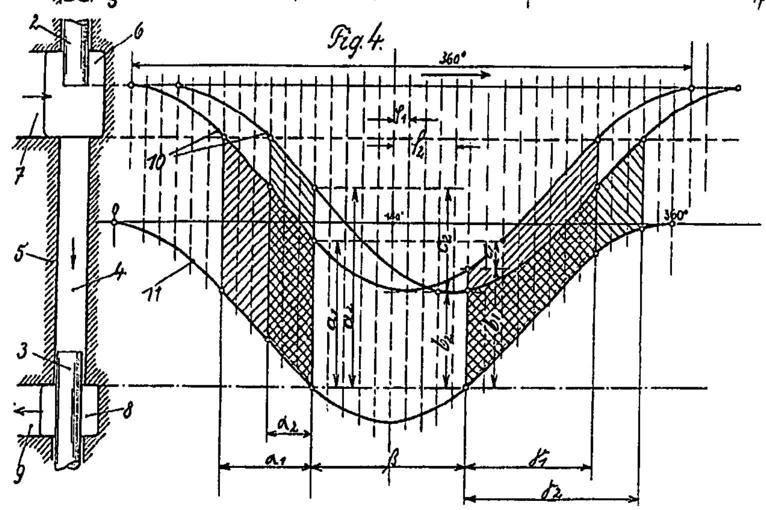

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Fig. 5.

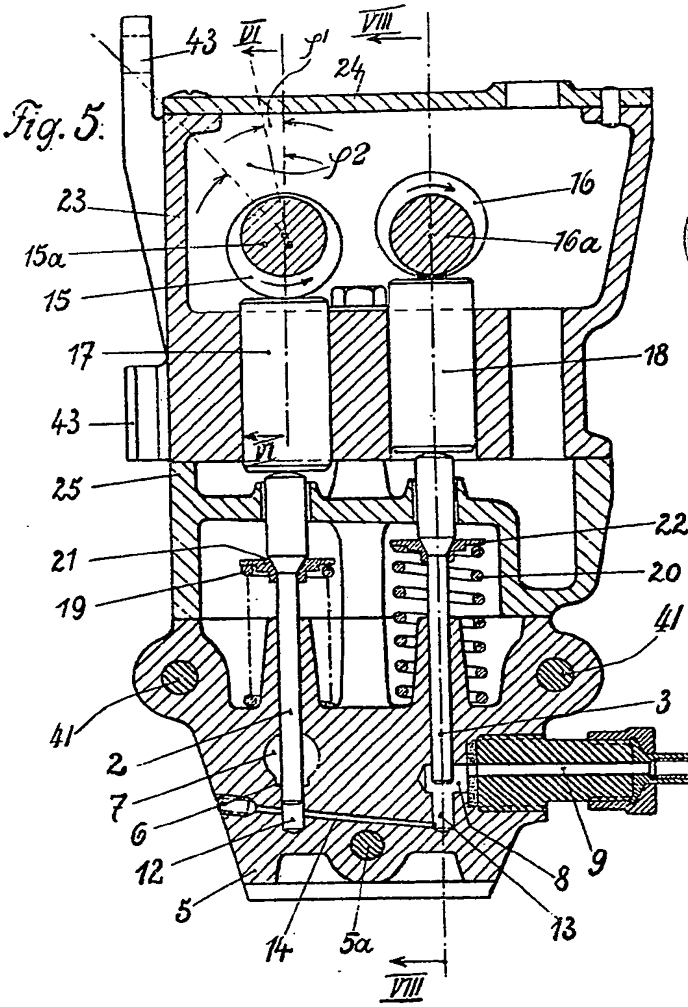


Fig. 8.

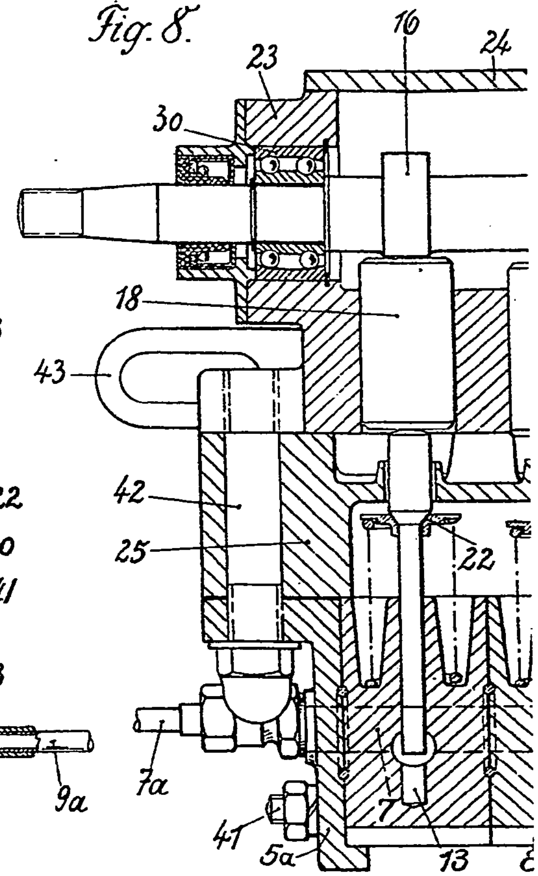
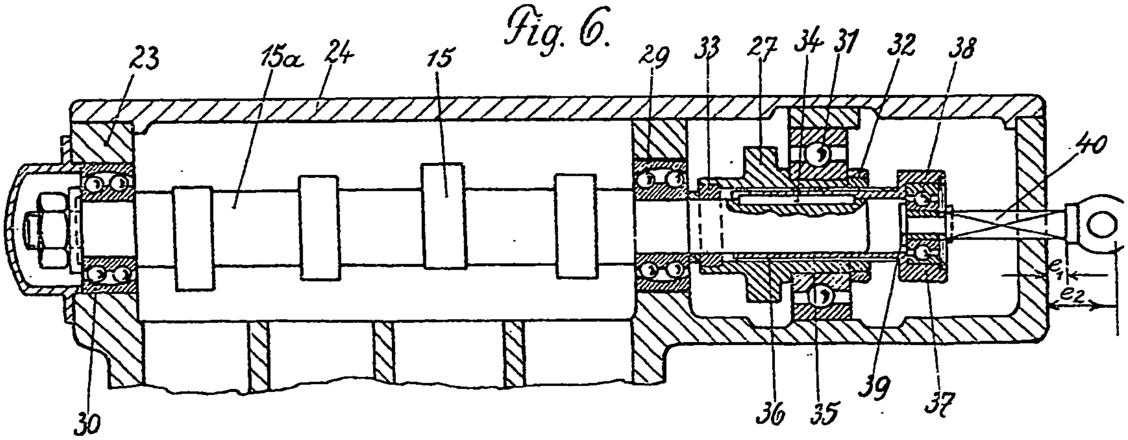
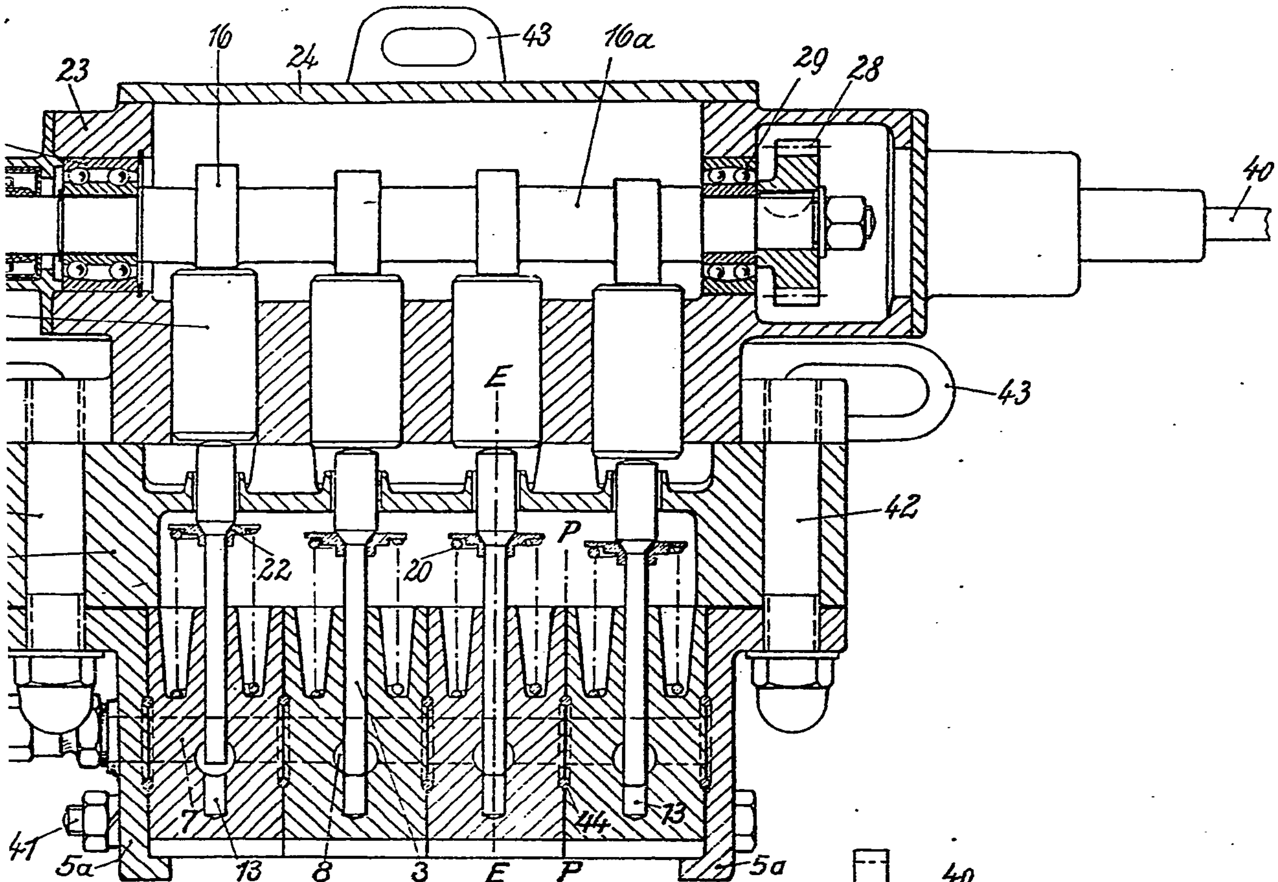


Fig. 6.

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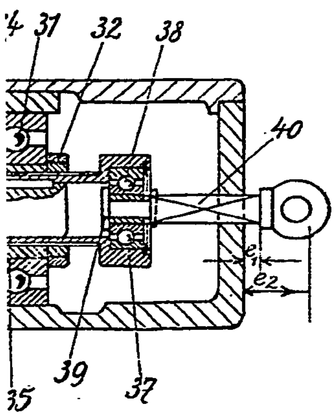
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Fig. 7.

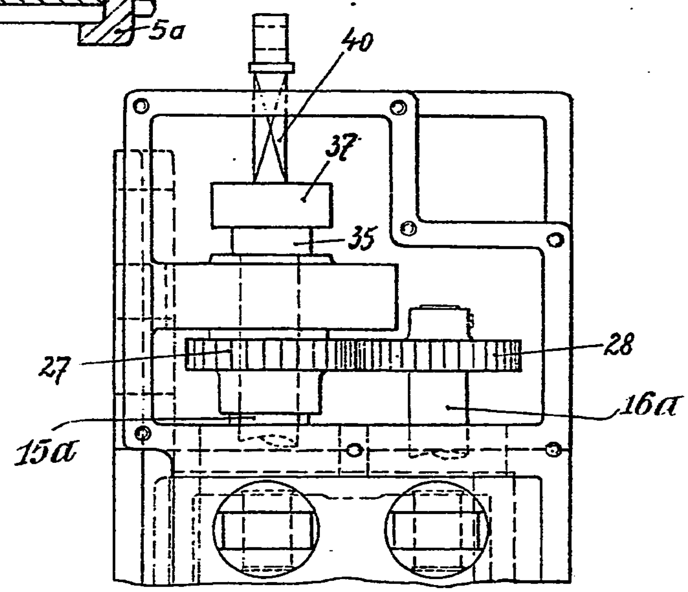
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Fig. 5.

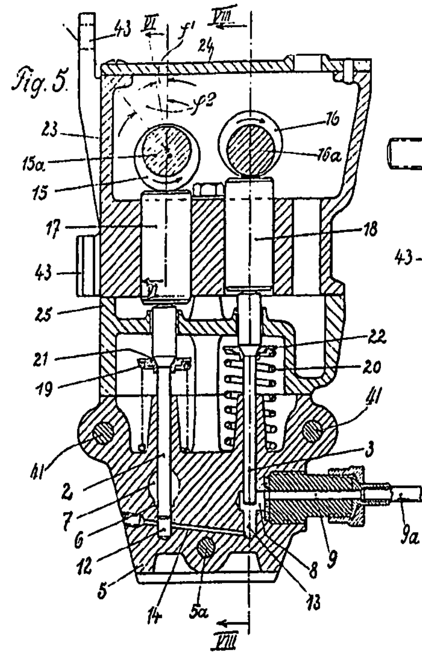


Fig. 8.

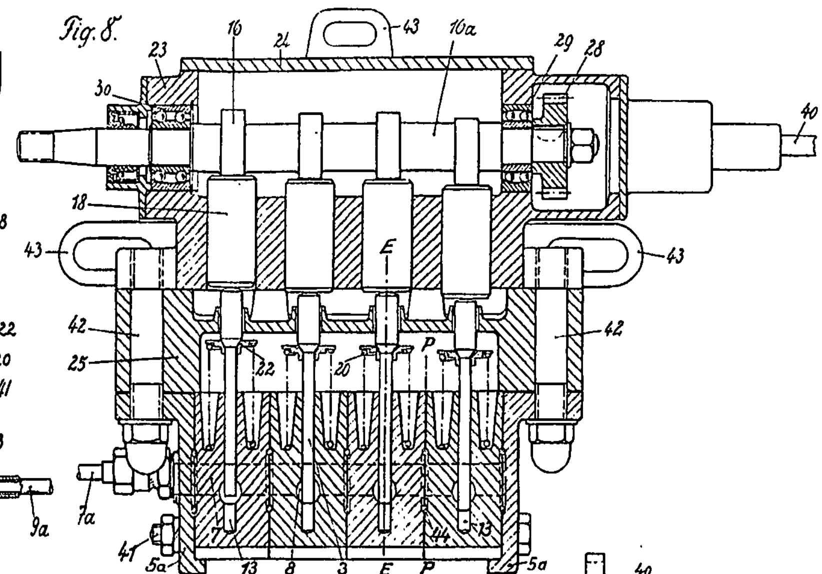


Fig. 6.

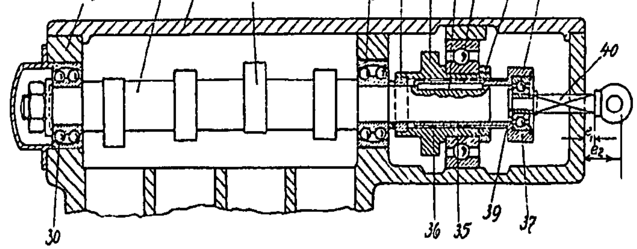
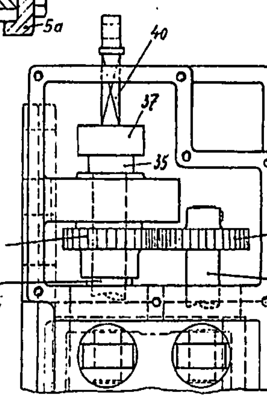


Fig. 7.



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